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THE CONTROL OF THE CODLING MOTH.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Entomology,
Washington, D. C., May 7, 1903.

Sir: I have the honor to transmit herewith the manuscript of a bulletin on The Control of the Codling Moth. This has been prepared in a condensed form by Mr. C. B. Simpson, a special agent of this office, from the extensive notes which he has taken during three years' investigation of the codling moth in the Northwest. On account of its probable value to apple growers I recommend that it be published as a Farmers' Bulletin.

Respectfully,

L. O. Howard, *Entomologist.*

Hon. James Wilson,
Secretary of Agriculture.

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INTRODUCTION.

Everyone is familiar with the injury caused by the codling moth (*Carpocapsa pomonella* Linn), but very few know the insect which causes the irregular cavity in the apple and renders it unfit for use.

If injurious insects were classified according to the monetary loss caused by them, the codling moth would undoubtedly rank first among insects injurious to fruits, as it causes more loss than all other fruit insects combined. It has been estimated that from one-fourth to one-half of the apple crop of the United States is either totally ruined or materially injured by it. In many large areas this insect would cause a total loss if it were allowed to take its natural course. By the use of the best measures of control the larger part of this loss could be prevented, as many apple growers in badly infested regions are saving from 85 to 98 per cent of their fruit each year.

DISTRIBUTION AND SPREAD.

The original home of this insect was most probably in southeastern Europe—the home of the apple. It has followed closely the distribution of the apple until it is now found in almost every country in the world, and is injurious in every apple-growing section of any importance in the United States.

It is spread principally by the shipping of infested fruits. When the fruit is picked and packed the young larvæ are often inside, and when they complete their development they crawl out of the fruit and spin cocoons. When the moths emerge they fly to the nearest orchard and deposit their eggs. When orchards are but little distance apart the moths fly from one to another. The system of returning empty boxes in which apples have been sent to market has, in many localities, hastened the local distribution.

FRUITS INFESTED.

The apple is the natural food of this insect and sustains almost all the loss occasioned by it. In most localities the Winesap and Lawver apples are usually less attacked than other varieties, while the Pewaukee and Ortley varieties are usually badly attacked. The resistance of

these and other varieties is variable and depends upon many local conditions. Pears are next in the order of infestation. If apples are present, pears are usually not badly infested, but if there are few apples and large numbers of the insect, the pears suffer a heavy loss. This insect has been noted feeding on the quince, prune, plum, peach, and cherry, but never in sufficient numbers to cause any great amount of injury.

LIFE HISTORY OF THE INSECT.

A good knowledge of the life history of this insect is the first essential to its control. Every fruit grower should familiarize himself with its different stages by studying the insect in his own orchard.

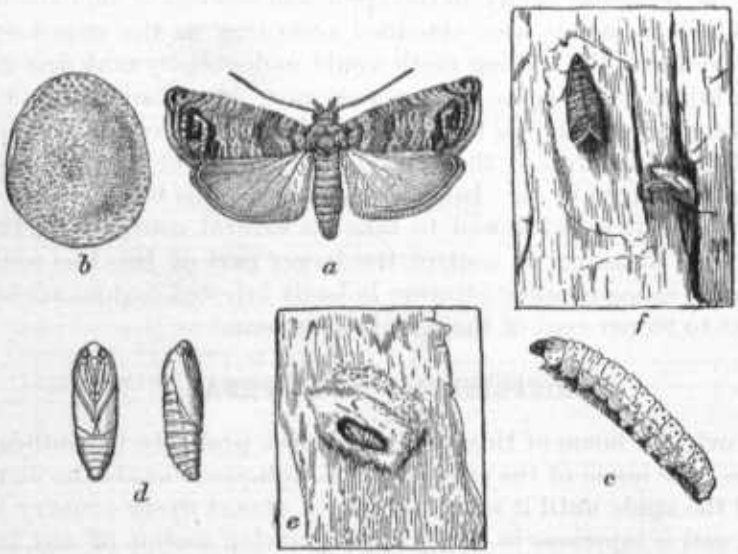

FIG. 1.—The Codling Moth: *a*, the moth or adult insect, slightly enlarged; *b*, the egg greatly enlarged; *c*, the full-grown larva, slightly enlarged; *d*, the pupa, slightly enlarged; *e*, the pupa in its cocoon on the inner surface of a piece of bark, reduced about one-half; *f*, moth on bark and empty pupa skin from which it emerged, about natural size (original).

HIBERNATION.

The codling moth passes the winter in the larval stage. The larvæ may be found encased in silken cocoons in cracks and holes in the trees and in houses where apples have been stored. In the spring these larvæ change to pupæ, from which the moths emerge about a week after the apple is in blossom.

THE MOTH.

The adult insect or moth (fig. 1, *a*) is but little known among fruit growers and other moths are often mistaken for it. It varies somewhat in size, but the maximum spread of its wings is about three-

fourths of an inch. The front wings are of a brownish-gray color and are crossed with lines of gray scales, giving them the appearance of watered silk. At the tips of the wings there is a large brown spot, in which are many scales of bronze or gold. The hind wings are grayish brown in color. Taken as a whole, the coloring of the moth is such that when resting on old grayish bark it is so like the bark that it is not easily distinguished.

The moth lays her eggs, a few days after emergence, on the leaves of apple or other food plant, or on the fruit. A majority of the eggs of the first generation are laid on the leaves, while the greater part of those of the second generation are laid upon the fruit.

THE EGG.

The eggs of this insect were never noted until within comparatively recent years. They are of a pearly white color and are like thin convex disks. Around the edge there is a coarse network of ridges, while toward the center these ridges are finer.

A red ring, which indicates the embryo, appears in the egg a few days after it is laid. In about eleven days (varying somewhat with temperature) the young larva breaks its way out of the shell and seeks to enter the fruit.

THE LARVA.

This is the most important stage of the insect, for not only does it do its injury in the larval condition, but that is the stage in which it is most amenable to remedial measures.

Recent work tends to show that a large number of the larvæ which hatch from eggs deposited on the leaves eat small portions of the leaves before finding fruit. The larvæ have some difficulty in entering the smooth sides of the fruit; hence they usually enter at the calyx or take advantage of some irregularity in the surface. About 80 per cent of the larvæ of the first generation enter the fruit by way of the calyx, while the majority of the second generation enter at the sides, especially where fruits are touching. Upon entering the fruit, the larva feeds immediately under the surface for a few days and then commences a tunnel toward the center of the fruit, where it eats out a large cavity. Frass and excrement which are thrown out characterize a wormy fruit. The larva, which is well known to all fruit growers, lives in the fruit about twenty days and grows pinkish or whitish, until it is about five-eighths of an inch in length (fig. 1, *c*), when, being full grown, it makes a tunnel to the outside of the fruit, the entrance of which is filled with frass and silk. When ready to leave the apple this plug is pushed out. The larva then crawls out and immediately seeks a place in which to spin its cocoon.

THE COCOON.

The places of spinning the cocoon vary with the surroundings. Cocoons have been observed in the following places: In holes and cracks in the trunks and branches of the trees; under rough bark; in the fruits (though rarely); in the cracks in the ground around the tree; on or between the clods among the fallen fruit; under bands or anything else resting on or against the tree; in cracks and angles of the walls and roof of the building in which apples are stored; under shingles of buildings near apple trees; in fence posts and under pickets of near-by fences; in paper or other rubbish on the ground; and in various other places. The cocoons of the first generation are composed entirely of silk, while in those of the second generation are incorporated bits of wood and bark. The larvæ inside the cocoons transform into pupæ in about six days from the time of spinning the cocoon.

THE PUPA.

The pupa (fig. 1, *d*) is yellowish at first, but changes to a brown, and later to a bronze color. The eyes, antennæ, mouth parts, wings, and legs of the adult insect are apparent. The movable abdominal segments are armed with two rows of spines. In about twenty days from the spinning of the cocoon the pupa, aided by the spines, pushes its way out of the cocoon. The pupa skin splits and the moth emerges (fig. 1, *f*), lays its eggs, and gives rise to another generation. The average life cycle of the insect is about fifty days.

GENERATIONS OF THE INSECT.

It has been found that in the principal apple-growing sections of the northern part of the United States the insect has one generation and often a partial second. In the warmer portions of the East and the West two generations are found. In the warmest parts of the West a partial third generation has been distinguished. Where two full generations occur the second is much more numerous and destructive than the first.

NATURAL ENEMIES.

There are many natural enemies of the codling moth which may be encouraged with advantage. It has often been noted that no larvæ can be found under the rough bark of the trees in the spring, while many are found in the cracks and holes in the trunks, branches, and stubs. Under the rough bark many cocoons can be found from which the larvæ are missing. A telltale hole made by a woodpecker can always be found. Destroying or rendering unsuitable the more secure places for spinning, thus forcing the larvæ to spin cocoons where the birds can get them, will result in destroying many of the insects.

MEASURES USED AGAINST THE CODLING MOTH.

The first essential in using measures against this insect is for the apple grower to familiarize himself with its life history. By doing this he is better prepared to understand the remedial measures recommended, and can modify them to suit his local conditions.

The means of control readily fall into two divisions—(1) preventive measures and (2) remedial measures.

In many newly settled districts of the West this insect has not yet made its appearance. By keeping all used apple boxes and infested fruit out of the district it may be a long time before the insect obtains a foothold. If it is present in small numbers, it may be practically exterminated by a strenuous application of the measures of control, but if present in great numbers it is impracticable to attempt its extermination. In many localities, by reason of the cold climate, the injury amounts to but little; in some years it may be no more than 5 per cent, while in others it may amount to 20 per cent. By using methods of control this damage can be materially reduced.

PREVENTIVE MEASURES.

Preventive measures are those means of control which are not only efficient against this insect, but are valuable in increasing the productiveness of the orchard, and the size, appearance, and quality of the fruit.

Measures for Use in Old Orchards.

The preventive measures to be used in an orchard that has just come into bearing are quite different from those required in one that has borne fruit for many years. The old neglected orchards are familiar objects in every section of the United States.

The writer has in mind two such orchards of different types of about 500 trees each. One is in the far West in an arid section, and the other is in the East in a humid section. Both are in localities of about the same average temperature. The Western orchard is about 18 years old; the trees are so close together (18 feet) that the branches of one tree touch those of the surrounding trees. The orchard has not been irrigated for many years; the soil is sandy, and on it grow many weeds; the bark of the trees is rough, the trunks and branches are cracked, and where branches have been cut off either holes or stubs remain. From lack of moisture the trees make but little growth and a few have died. The fruit is abundant, but undersized. For the past three seasons this orchard has been under the observation of the writer, and in that time not over 3 or 4 boxes of good apples free from the work of the codling moth have been produced.

In the Eastern orchard the trees are in sod and about 40 feet apart. There are many stubs of broken branches in which the larvæ hibernate. The fruit has always been abundant, but is practically all infested by this insect.

The woodpeckers have done much effective work in both these orchards by digging out and eating the larvæ. Other insects may be attacking the trunks of the trees or eating the leaves. Practically no revenue is derived from either of these orchards, but, on the contrary, they are a constant source of loss.

Many farmers who have orchards similar to those just described believe that the only thing to be done is to cut down the trees and start new orchards instead of renovating the old. These orchards can be restored quite easily and made to produce profitably for many years. Work should be begun late in the fall or early in the spring, and the treatment should be about the same in both cases, except that the Western orchard should be irrigated freely, and every second tree should be cut out. In both orchards the soil should receive a very shallow cultivation for a year and a dressing of manure. The following year cover crops, such as cowpea or red clover, should be sown and plowed under, and this should be repeated every few years. Branches should be cut out where they are matted together, thus allowing access of the sunlight and spraying solution. In the West a thick foliage is often an advantage in protecting the fruit from the sun and thus avoiding sunburn. The dead branches and stubs should be cut away and burned. It is highly important that the cut ends be smooth and dressed with shellac varnish or grafting wax. All of the rough bark should be scraped from the trunks and larger branches. The holes in the tree should be filled with plaster or cement, thus confining all larvæ that are in them and preventing others from entering later in the season.

If proper attention is given an orchard when it is young, no such work will ever be necessary.

Measures for Use in Young Orchards.

If a young orchard is to be planted in a badly infested locality, this insect must be considered from the very first if any degree of success is to be achieved. The question of varieties is largely a question of climate, soil, and the demands of the market. The Winesap and Lawyer varieties are always resistant to this insect, and the Ortley and Pewaukee are always badly infested. Late winter varieties are usually less infested than the fall varieties, and in some sections of the country the early apples are harvested before the second generation of the insect attacks the fruit. The trees should never be planted nearer together than 30 by 30 feet in order that a spraying machine and wagon may have plenty of space between the rows. They should

lean toward the southwest, so that the tops will shade the trunks, thus in a measure avoiding sun scald, the effects of which furnish secure places in which the codling moth larvæ can spin their cocoons. The pruning of a tree when it is young is of the utmost importance. If the tree grows too high it is difficult to spray when it is full grown; if too low the branches lie on the ground and the same difficulty occurs. It is expensive to pick the fruit from high trees, and when the lower branches are on the ground the fruit upon them will be uncolored. A good average between the high and the low trees is to be desired. If only two or three main branches grow out from the trunk they will nearly always split apart under the weight of a full load of fruit. When such a branch is put in place and held either by a bolt or a wire, the crack made by the splitting is an attractive place for the insects. In many orchards it has been observed that trees thus injured always have a higher percentage of wormy fruit than those which are uninjured. This splitting may be prevented by pruning, so as to cause many branches to form the body of the tree, and cutting back about half of each year's growth, so as to make the tree stocky and able to bear the excessive weight; by thinning the fruit; or by propping the limbs.

By planting clover in an orchard, not only is the soil benefited, but the ground is kept moist; and because they dislike moisture the larvæ will not spin cocoons in the ground around or near the tree.

Thinning fruit.—In the Pacific Northwest the thinning of apples is a practice that is badly neglected. As a result, much of the fruit is small, uncolored, and consequently inferior in value. The advantages of thinning in producing better fruit are too well known to need discussion. All of the terminal clusters should be thinned to one fruit and fruits should not be allowed to grow closer together than 6 inches. The thinning should be done when most of the codling-moth larvæ of the first generation are in the fruit. In the Pacific Northwest thinning should be done between June 15 and July 1. In other localities this work may be done earlier or later, but observation can determine the time with reasonable accuracy. In thinning, special care should be taken that as many of the wormy apples be picked as is consistent with the rapidity of the work. The wormy fruit thus removed from the trees should be buried, being covered with at least 6 inches of earth. It has often been recommended that the windfalls be gathered every few days and destroyed. In a small orchard this is practicable, but in a large commercial orchard it would be far too expensive.

Packing fruit.—The place of packing the fruit is of the greatest importance when the codling moth is considered. The best plan, and the one which is being generally adopted among the best Western orchardists, is to have the packing done in the orchard. A movable packing table is made upon runners and this is drawn through the

orchard. As the apples from two rows of trees on either side are picked, they are carried to the table by the pickers. By this method the apples are not moved any considerable distance until packed, and the danger of bruising the fruit is thus reduced to a minimum. If infested fruit is taken into a packing house, the larvæ crawl out of the fruit and spin their cocoons in the cracks and angles of the building. In the spring the moths emerge and fly to the orchards. By packing in the orchard the wormy fruit is piled up, and the larvæ for the most part spin cocoons among the apples.

Many apple growers make the mistake of selling or trying to sell wormy apples as first-class fruit. It is a difficult thing to pack a box or barrel of apples and not put in a single imperfect apple, but the ideal of perfect fruit should be the growers' guide. Second-class apples should be packed and shipped as quickly as possible. The culls and windfalls should be promptly made into cider for vinegar or disposed of in some other way, thus preventing the escape of the larvæ. If they are not so used, they should be buried. Experiments in burying culls and windfalls have shown that when the larvæ leave the fruit they spin their cocoons on or between the apples and rarely try to reach the surface of the ground. If the larvæ survive, the moths which emerge die, as they can not reach the surface of the ground.

Storing fruit.—It is a great mistake to store infested fruit near an orchard, as when the moths emerge in the spring they fly to the orchard, and in many cases a large percentage of the fruit near the storehouse is infested. The writer has studied several cases where this was true, and in each case the resulting loss could have been averted. If the fruit must be stored, the house in which it is stored should have no cracks or holes through which the moths can escape. A tight house can be fumigated with hydrocyanic-acid gas or with sulphur. A simpler way is to crush the moths when they have gathered on a window or on a screen; or, if left in the storeroom, they will die in a week or so.

REMEDIAL MEASURES.

Remedial measures against the codling moth are those from which little or no benefit is derived, except that of saving the fruit from attacks of the insect.

Remedies of Little or no Value.

It is sometimes as well to know what not to use against an insect as it is to know what to use. The following remedies have been at various times suggested and have been found to be of little or no value: Moth balls hung in the trees and supposed to keep moths away; smudging orchards with ill-smelling compounds; plugging the trees with sulphur; plugging the roots with calomel; banding trees with tarred

paper to keep the larvæ from crawling up the tree; trap lanterns; baiting the moths with mixture of vinegar and molasses; spraying with ill-smelling compounds; spraying with water; and electric lights as a repellant of the moth. These so-called remedies have been tried so often that a fruit grower is simply wasting his time and money when he uses them.

Spraying with Arsenical Insecticides.

The efficiency of sprays against this insect was discovered in spraying for canker worms, which feed upon the leaves of the apple. Since that time the machinery and the solutions used in spraying have been greatly improved, and now this method is well known to be the best and most efficient.

Many farmers have a deeply rooted objection to spraying on general principles. They have never sprayed, and many of them are proud of the fact that they do not spray their orchards, even if they lose the larger part of their fruit which otherwise might have been saved. The more progressive and business-like apple growers are the stanchest advocates of spraying, and their efforts are uniformly successful. Experience gained by several years of spraying always brings about greater efficiency and a reduction of expenses. A fruit grower who wishes to begin spraying can well afford to study the spraying operations in other orchards and familiarize himself with the general methods.

Spraying Machinery.

The kind of spraying outfit depends upon many factors, the principal one being the number and size of the trees.

Hand-power outfits.—For an orchard of 1,000 trees or less the writer would advise the use of a hand-power outfit. The capacity and cost of this machine should depend upon the size of the orchard. There are many excellent makes of spray pumps upon the market, and a pump can be easily chosen to suit the conditions in various orchards. The working parts of the better and more expensive pumps are made of brass or bronze. It is desirable that a pressure gauge be attached to the pump, in order that the man pumping may keep up a constant pressure. More than two lines of hose result in confusion and cause loss of time in an orchard. Bamboo or iron extensions should be used in order to reach the tops of the taller trees. There are two types of nozzle, either of which may be used for this work—(1) those which give a fan-shaped spray and (2) those which produce a cone-shaped spray. The former is better adapted to long-range work and the latter to close-range work. As many as 3 or 4 of these nozzles may be used to advantage on one line of hose, but 2 is the usual number. It is a great advantage to have the nozzles set at an angle from the axis of the extension, as by simply turning the extension the spray can be

thrown in all directions among the branches. The spray must be applied with great force (60 to 100 pounds or more) in order that the stream be broken into a fine mist.

The tank may vary from a 50-gallon barrel to a tank of 250 gallons capacity, which may be mounted on an ordinary wagon; a barrel may be hauled on a sled. The tanks should be solidly built and held together with iron rods. If the trees are tall, it will be found to be of great advantage to have a platform erected on the wagon upon which the

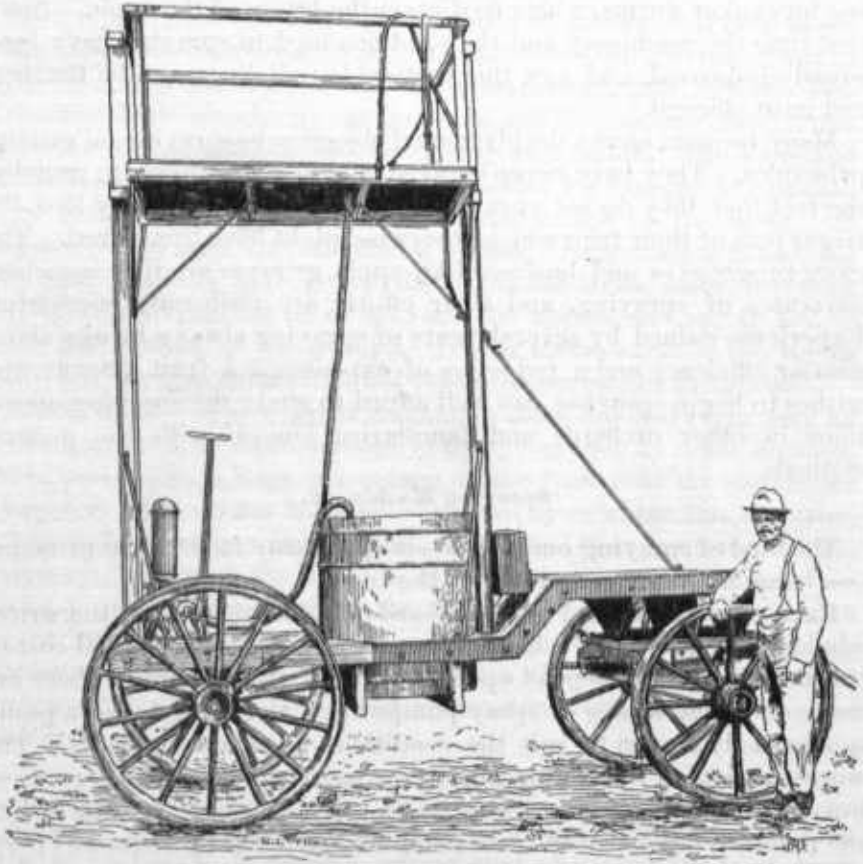

FIG. 2.—Spraying outfit for treating tall trees—(after Gould).

men can stand (fig. 2). The capacity of the hand-power outfit depends upon many factors, as distance of water supply, size of trees, and number of men and nozzles. Three men with a 200-gallon tank and 2 lines of hose, each fitted with 2 nozzles can spray about 250 average-sized trees per day.

Gasoline-power sprayers.—If an orchard of more than 1,000 trees is to be sprayed, it will be found advisable to use a gasoline-power outfit (fig. 3). Many dealers in spraying apparatus have placed machines

of this kind upon the market. A majority of these are well adapted to the work for which they are intended, but many valuable improvements can yet be made which will increase the efficiency of these machines with but little cost. In general, the size of engine to be preferred is 1 horsepower. The cooling tanks used with the engines are intended to be used when the water can not be renewed frequently, and are about 1 foot in diameter. In spraying, the water can be renewed often and the weight can be reduced considerably by making these tanks of a much smaller diameter. Purchasers are always given full directions in regard to the care and running of the engine, so that ordinarily but little difficulty is met. The engine is best placed at the rear end of the wagon frame and the pump as near to it as possible. There are several types of pump which can be used in this connection. Brass working parts which can be easily

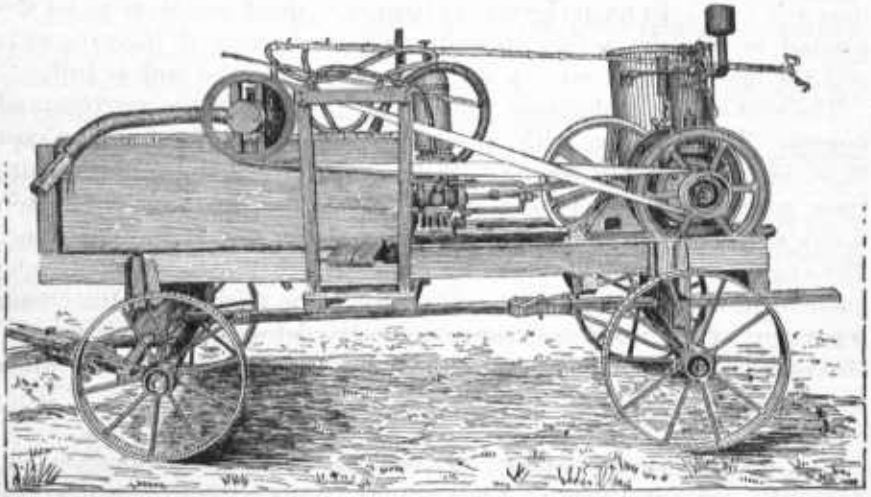

FIG. 3.—Gasoline power spraying outfit (original).

removed are preferable. A pressure gauge and a large air chamber are necessities. For filling the tank another pump of the "low-down" type can be used advantageously when the water supply is to be drawn from a stream or irrigating ditch. This extra pump and necessary connections can be purchased for about $20, and in a season will pay for itself many times over by the saving of time and labor. The gasoline engines are usually fitted up for running such a pump by means of a connecting rod which can be attached to the piston of the pump. While filling the tank the spray pump can be disconnected or, more easily, the suction hose can be taken out of the tank. The tank may be made of wood or of galvanized iron. It should be thoroughly braced and should never be made to hold over 150 gallons. It should be placed nearest the horses, because of its great weight when full of the spraying solution. The best agitator is a paddle wheel, with pad-

dles placed at an angle on a vertical shaft. By means of bevel gearing and a belt, power is obtained from the engine. The engines, pumps, and tank are mounted on a solid frame, which is placed upon a low wagon. The low steel-wheeled wagons are highly preferable, as the tires, which should never be less than 6 inches wide, prevent the machine from sinking into the soft earth. Platforms can be built on the sides, upon which the operator can stand. With a bamboo extension and long-range nozzles set at an angle every part of the trees can be easily sprayed. Only two men are needed to operate this outfit: One drives, the other starts and stops the engine, and both spray. With this machine 700 8-year-old trees can easily be sprayed in one day; by rushing, more may be done. It takes from four to five minutes to fill the 150-gallon tank and from thirty to forty minutes to spray out the same amount on from 60 to 80 trees, using about 2½ gallons per tree. In an irrigated orchard care must be taken to let the ground become dry before spraying is done, because if the ground is soft the machine may mire down, especially when the tank is full.

The cost of these machines varies with the cost of the engines and pumps. The machine with which the writer is most familiar cost $320, including a $40 wagon. With good care and proper repairs these machines ought to last many years. In a working day of ten hours a 1-horsepower engine consumes about a gallon of gasoline. The engine can be made to pay for itself by other uses which may be made of it, such as running the cider press, the feed cutter, the cream separator, or the wood saw, turning the grindstone, and doing numerous other things. The wagon can be used for other purposes when not needed for spraying.

Spraying materials for use against the codling moth.

Contact insecticides.—The insecticides which kill by touching the insects, such as kerosene emulsion and whale-oil soap, applied frequently, have in a few experiments been found efficient against this insect. On account of the expense and the necessity for frequent application they have never been used to any extent.

Arsenical sprays.—The arsenical sprays contain arsenic as the poisonous ingredient. There are several of the spraying compounds upon the market and many others which the fruit grower can prepare himself.

Paris green is probably the best known of these arsenicals. It is a definite chemical compound of arsenic, copper, and acetic acid and should have a uniform composition. It is a rather coarse powder and has the fault of settling rapidly. In the East it costs 20 cents a pound, while in the West the cost is 25 cents.

Paris green may be prepared for spraying as follows:

Paris green	pounds..	1
Lime	do....	1 to 2
Water	gallons..	100 to 250

The lime should be fresh and should be slacked in quantities as needed. Mix the Paris green with a little water until a paste is formed, and then add this to the required amount of water, to which the lime has been added. A good average strength to use is 1 pound to 150 gallons, but it must be weaker on trees with delicate foliage, such as peach. Many fruit growers are using it on apple trees as strong as 1 pound to 100 gallons.

Scheele's green is similar to Paris green, but differs from it in lacking the acetic acid. It is a much finer powder than Paris green and more easily kept in suspension, and it costs only about half as much.

London purple is a waste product in the manufacture of aniline dyes and contains a number of substances, the principal ones being arsenic and lime. It is variable in composition, is not so effective as the other poisons, and is now but little used for spraying.

Scheele's green and London purple are prepared for spraying in the same way as Paris green.

White arsenic compounds, made by combining other chemicals with white arsenic, form a class of excellent spraying materials. Arsenic used alone seriously burns the foliage.

Arsenite of lime.

White arsenic	pounds..	1
Lime	do....	2
Water	gallon..	1

These ingredients are boiled together for not less than half an hour, as it is quite difficult to make the lime and arsenic combine. Pour in water enough to replace that lost by evaporation. To every 40 or 50 gallons of water use 1 pint of this stock solution. It is advisable to add more lime to the spraying solution, in order that there will be less danger of burning the foliage.

Arsenite of lime with soda.

White arsenic	pounds..	1
Sal soda (crystal)	do....	4
Water	gallons..	1

The above ingredients are boiled until dissolved, which will be in a very few minutes, and the water lost by evaporation is then replaced. To 40 or 50 gallons of water a pint of this stock solution and 2 to 4 pounds of freshly slacked lime are added. This excess of lime is always desired by fruit growers, as they can then see by the amount

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and distribution of the lime on the foliage how well the spraying has been done. This formula has been thoroughly tested by the writer and others and has been found not only as efficient as the other solutions, but far cheaper.

Arsenate of lead.

Arsenate of soda	ounces	10
Acetate of lead	do	24
Water	gallons	150–200

These ingredients should be dissolved separately and then poured into the tank containing the water for spraying. They unite readily, forming the flocculent white precipitate of lead arsenate. This is easily kept in suspension and can be used in excessive strengths on delicate plants without the addition of lime. There are several preparations of lead arsenate on the market which are excellent, some being in a wet state and others in dry, powdered form. The wet preparations are preferable, as the dried arsenate does not give such a filmy and adhering coat to the foliage.

At all times the greatest care should be taken to prevent accident with these compounds, which are of the most poisonous nature.[a] All packages, boxes, or bottles containing these materials should be plainly labeled and kept in some place that can be securely locked. The utensils in which the mixtures are prepared should be thoroughly cleansed.

When it is desired to use a fungicide with any of these solutions the arsenites are added to the Bordeaux mixture in the same proportion as it would be added to water.

Cost of Spraying Material.

The cost of the different arsenical compounds varies in different sections of the country in accordance with the freight rates and the quantity purchased.

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[a] Although no accidents have ever resulted from the use of arsenicals in spraying, it is well enough to know what to do in a case of accidental poisoning. If any evil effects are noted in case of persons who constantly handle these poisons, a physician should be consulted. If by any mistake or carelessness a small quantity is swallowed, an antidote should be employed without delay. Ferric hydrate, which forms an insoluble compound with arsenic, is the best; lime water may be used, but is less effective. Some emetic, such as mustard in warm water, should be taken immediately after the antidote. The Ferric hydrate should be freshly prepared by adding strong ammonia to the solution or tincture of ferric chlorid. Both chemicals are kept in all drug stores. In preparing the ferric hydrate, continue to add ammonia until, after being well shaken, a faint odor of ammonia can be observed; an excess of this ingredient is decidedly injurious. Persons who use arsenical sprays are advised to keep a small bottle of each of the chemicals used in making ferric hydrate on hand for use in case of emergency.

The cost of 600 gallons of the different spraying solutions just described is, in the far West, as follows:

Paris green:	
Paris green, 4 pounds at 25 cents	$1.00
Lime, 8 pounds	.04
Total	1.04
Scheele's green:	
Scheele's green, 4 pounds at 12½ cents	.50
Lime, 8 pounds	.04
Total	.54
Lime arsenite:	
White arsenic, 1½ pounds at 10 cents	.15
Lime, 3 pounds	.015
Additional lime, 12 pounds	.06
Total	.225
Lime arsenite with soda:	
White arsenic, 1½ pounds at 10 cents	.15
Salsoda, 6 pounds at 1½ cents	.09
Additional lime, 6 pounds	.03
Total	.27
Lead arsenate:	
Arsenate of soda, 2½ pounds at 10 cents	.25
Acetate of lead, 6 pounds at 12 cents	.72
Total	.97
Prepared lead arsenate, 36 pounds at 20 cents	$7.20

Any fruit grower can estimate what these spraying solutions will cost him by finding what these chemicals cost in his section. The cost of the prepared lead arsenate is prohibitive for a commercial orchard, but in case of a home orchard of but few trees it saves a large amount of labor and is much used in such cases.

Cost of spraying.

The cost of spraying is practically nothing when compared with the benefits derived. As in other lines of work, exact methods and cutting off every unnecessary expense will reduce the cost considerably. The estimates given herein are based on data obtained in the field when spraying operations were in progress. The spraying of 1,000 trees once is taken as a basis for calculations under Western conditions. In localities where labor and material are cheaper the cost will be considerably lower.

Hand-power spraying outfits can be purchased and put in working order for from $15 to $75. The gasoline-power outfits can be purchased complete for from $280 to $400. A hand-power sprayer, if used for arsenites alone and given good care, ought to last five or six years with but few repairs, and the gasoline sprayer can be made to last as long. By using the engine for purposes other than spraying it can be made to pay for itself.

The principal cost of spraying is the labor, as the material is comparatively a small item. The cost of spraying 1,000 8-year-old trees in the West once with arsenite of lime with soda using 2½ gallons per tree is as follows:

Hand-power outfit:	
Man and team 4 days, at $3.50	$14.00
Two men 4 days, at $1.50 each	12.00
Materials	1.12
Total	$27.12
Gasoline-power outfit:	
Man and team 1½ days, at $3.50	5.25
One man 1½ days, at $1.50	2.25
Materials	1.12
Gasoline, 1½ gallons	.55
Total	$9.17

The above estimates are for labor in the far West and would be much less in the East. It is considered that the team and labor are employed at the current rates; but as teams and men are already employed on all farms, this cost is far in excess of what it would actually cost the farmer. According to the preceding estimates it would cost 2.7 cents per tree with hand power and .9 cent per tree with gasoline power. The additional cost of spraying to the fruit grower would be about 1 cent per tree with hand power and about ½ cent per tree with gasoline power.

How to Apply the Spray.

The spray should be applied to the leaves and foliage so that a thin coating will remain after the water has evaporated. To do this the spray should be applied with great force so as to form a dense mist. At all times the solution in the tank should be kept thoroughly agitated, especially if Paris green is used. Probably the most rapid progress in spraying can be made in the following way: Drive the outfit between two rows and spray half of each tree in each row. The routes followed in an orchard should be governed by the position of the water supply. If the wind is blowing it is best to go parallel with it rather than at right angles to it, and advantage may be taken of the wind by allowing it to blow the mist into the trees.

Time of application of spray.

The most important consideration in spraying is the time of the application. The time of application for the codling moth should depend entirely upon the stage of the insect, as the greatest efficiency is obtained by spraying just when the larvæ are entering the fruit or immediately before. The sprayings may be designated as "early" and "late." The early sprayings are directed against the first generation of the codling moth. Two of these sprayings are advised, one a few days after the blossoms have fallen and before the calyx closes, and the other two weeks to a month later, when the larvæ are entering the fruit. In cases of bad infestation, when the preventive measures have been neglected, another spraying may be added. In the West the evidence goes to show that the spraying immediately after the blossoms fall is not so effective as it is in the East. Some are of the opinion that it should be dispensed with; but in view of our lack of knowledge on this point, the writer does not think that the evidence at hand fully justifies discouraging this spraying in the West.

The later sprayings are directed against the larvæ of the second generation when they are entering the fruit. The time this generation enters the fruit varies with the locality and the seasons in the same locality, but it is easily found by watching the fruit for the first new entrance holes; or spraying may be commenced about twenty-one days after the date when the largest number of larvæ of the first generation are ready to spin their cocoons. The larvæ of the second generation usually begin to enter the last week in July, and the majority enter in August, while a few enter in September. The number of sprayings to be made against this second generation depends upon the efficiency of the preventive measures and the early sprayings. Two sprayings are usually sufficient; but if infestation is bad, three should be made. The quantity of lime used in the last spraying should be reduced to the minimum required, as the lime on the ripe fruit reduces its market value.

Light showers have but little effect in washing away the spray, but a continued rain or a heavy shower makes it necessary to repeat the spraying. The lead arsenate is less affected by rain than the other compounds.

The young larvæ are killed by the poison they eat before they have entered the fruit. They get it in the calyx, on the sides of the fruit, or on the leaves. Recent work tends to show that a great many get the poison by nibbling the poisoned leaves.

BANDING.

The use of bands to trap the full-grown larvæ of this insect was the only remedial measure of value before the use of arsenical sprays was

discovered. When an orchard has been given good care, preventive measures have been fully carried out, and spraying is thoroughly done with a gasoline-power outfit, it is unnecessary to use bands. If, however, the trees are old, have cracks and holes in the trunks and branches, and are close together, so that the spraying can not be well done, it is quite necessary to use these bands; or if it is desired to bring the insect under control in a badly infested orchard, the bands can be used with good success as an additional method to spraying.

FIG. 4.—Large apple tree properly banded for the codling moth (original).

Banding for this insect in general is simply offering a good place, in which the larva will spin its cocoon and killing it after it has done so. Cloth bands, from 10 to 12 inches in width, are folded once lengthwise and placed around the tree. They can be fastened in such a way as to be easily removed and replaced by driving a nail through the ends and then nipping off the head at an angle so as to leave a sharp point. If a tree is large, one band should be placed on the trunk and one on each of the larger limbs. (Fig. 4.) Cloth bands of any heavy, dark-colored stuff are much preferable to bands

of hay or paper. When bands are used, other places in which the larvæ might spin cocoons should be destroyed or rendered unsuitable. It is, of course, a most important point that the larvæ which go under the bands be destroyed. To accomplish this the bands should be inspected regularly at intervals of ten days. At best, banding is but little effective in badly infested localities if used alone, but it is a most valuable adjunct to spraying.

CONCLUSION.

The results secured against this insect by these methods under the different conditions found in the various apple sections of the United States are very satisfactory. In the infested sections of the far West, if no measures are used, from 85 to 100 per cent of the fruit is injured. By an intelligent application of these preventive and remedial measures many practical tests show that from 85 to 98 per cent of the fruit may be saved.

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The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent to any address on application to any Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. The missing numbers have been discontinued, being superseded by later bulletins.

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